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Bibliometric Mapping of Research on Mathematical Representation Ability in Indonesia (2020–2025)

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ABSTRACT

This study analyses publication trends in the study of mathematical representation ability in Indonesia using a bibliometric approach. A total of 71 articles published between 2016 and 2025 were analysed, with a focus on the period from 2020 to 2025. Data were collected from Publish or Perish, SINTA, Open Knowledge, and Scopus, and then analysed both quantitatively and descriptively based on the year of publication, journal indexation, research method, citation, and keywords. The results indicate that publications reached a peak in 2022 and then declined from 2023 to 2025. Of all the articles analysed, 77% were published in national journals, while international publications were still very limited. Furthermore, the dominance of qualitative methods is 62%, followed by quasi-experimental and quantitative methods. Keyword analysis revealed a major cluster of "mathematical representation abilities" that are heavily associated with student characteristics and learning strategies. This study offers a comprehensive overview of the development of mathematical representation research in Indonesia, highlighting the need to expand scientific collaboration and enhance representation competence in future education policies.

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1. INTRODUCTION

The development of 21st-century education requires students to possess high-level thinking skills, including the ability to represent mathematical ideas precisely. The world is currently facing major changes, marked by the Industrial Revolution 4.0 [1]. Curriculum and learning have an important position in the national education system [2]. The *National Council of Teachers of Mathematics* (NCTM) states that in mathematics learning, there are process standards, including problem solving, mathematical reasoning and proof, mathematical communication, mathematical connections, and mathematical representation [3]. The five standards will be interrelated.

From the latest results of the *Programme for International Student Assessment* (PISA) 2018, Indonesia was ranked 73rd out of 78 countries that participated, and received a reading score of 371, a mathematics score of 379, and a science score of 396, with the OECD average of 487, 489, and 483, respectively [4]. From this, it can be seen that mathematical ability is quite low, being 110 points below the average standard. This reinforces his low ability to think logically, representationally, and solve mathematical problems. Nevertheless, many studies have found that students' mathematical representation abilities are still low, especially in visual and symbolic forms [5].

Various learning approaches and models have been implemented in an effort to improve the ability of mathematical representation, including *problem-based learning* [6], STAD and TPS models [7], realistic mathematics [8], and inquiry [9]. However, so far, there has been little research that systematically maps the development of the study of mathematical connections in Indonesia. Information about the level of education that is most often the focus, commonly used research methods, and dominant topics or keywords are still not thoroughly documented.

Therefore, to facilitate an understanding of the mathematical representation, the literature is systematically reviewed and mapped. One approach that can be employed is the use of bibliometric analysis. Until now, studies that systematically map the development of mathematical representation research in Indonesia are still limited. Bibliometric analysis is used to map publication trends, patterns of collaboration, and emerging topics in a research field, as well as provide comprehensive methodological guidance on its implementation and steps [10], [11]. Through a quantitative approach, bibliometric analysis enables researchers to map publication patterns, identify high-productivity journals, uncover dominant research topics, and pinpoint areas that remain open to exploration [12].

Based on the background described, this study employs a bibliometric approach to analyse the development of research on mathematical representation. The mapping was carried out on 71 articles published between 2016 and 2025, but was limited to analysing the 2020-2025 range, by reviewing the distribution of articles by year, journal indexation (SINTA, Scopus, and unindexed), research methods, highest citations, and most frequently used keyword maps. In contrast to the previous descriptive review, this study systematically measured trends, publication patterns, journal indexation, research methods, dominant keywords, and articles with the highest citations to provide a comprehensive overview of the development of mathematical representation research in Indonesia. The results of this mapping are expected to make a significant contribution to researchers, educators, and policymakers in designing more relevant and future-oriented mathematics learning research and reform.

2. METHOD

Bibliometric analysis is a descriptive, quantitative method used to analyse scientific literature, focusing on publication data and citations to identify patterns, trends, and structures in the research literature [13]. Bibliometric analysis is employed as a quantitative and descriptive approach to identify patterns, trends, and publication structures

related to mathematical representation capabilities. This study analysed 71 articles published between 2016 and 2025, with a focus on the analysis period from 2020 to 2025. Data was collected from *Google Scholar* using *the Publish or Perish tool*, as well as from SINTA, *Open Knowledge*, and Scopus. The search was conducted using the main keyword "mathematical representation ability." Articles were included based on the following criteria: they were related to the topic, published in a scientific journal, and fell within the 2016–2025 timeframe, providing complete metadata. Meanwhile, duplicate articles, proceedings, non-scientific documents, and publications without adequate metadata were excluded from the analysis.

All metadata obtained is compiled using Microsoft Excel and managed through Mendeley to maintain reference consistency. The analysis process was carried out through several stages [10], starting with data collection using a single search query, followed by data cleansing, which involved eliminating duplication and filtering for the suitability of topics and document types. After that, each article is coded based on bibliometric variables, including the year of publication, journal indexation (SINTA, Scopus, or unindexed), research method, number of citations, level of education, and keywords. The final stage involves visual analysis using VOSviewer version 1.6.20 to map the relationship between keywords (co-occurrence), allowing for a comprehensive view of the patterns of interconnectedness between concepts in mathematical representation research. This study utilised publicly available metadata and did not involve human participants; therefore, it did not require additional ethical approval.

3. RESULTS AND DISCUSSION

3.1. Annual Publication Trends (2020-2025)

Figure 1. Annual Publication Trends on Mathematical Representation Research (2020-2025).
Data source: Author dataset

From the results of the classification of publications, the number of studies that discuss the ability of mathematical representation has increased and decreased from year to year. The classification derived from the 71 research articles is limited to the range of 2020

to 2025. Publication activity began to increase in 2020, with 8 articles, and then reached its peak in 2022 with 17 articles published. The increase observed in 2022 indicates that research into mathematical representation capabilities has been growing in recent years. This trend aligns with the research of Irvansyah et al., who found that mathematical representation is one of the themes widely researched in mathematics education in Indonesia [13].

It has also been suggested that a bibliometric analysis of communication skills and mathematical representation shows a surge in the number of articles over the last five years [14]. This strengthens the ability of mathematical representation, which is a key research focus in mathematics education.

However, between 2023 and 2025, the number of publications began to decline (19 articles in total), which is likely due to a shift in research focus to other topics, such as numeracy literacy or technology integration. These findings align with the bibliometric mapping of numerical literacy in Indonesia and studies that indicate a surge in publications related to this topic.

A new research concentration on numerical literacy relevant to the Indonesian context [15]. Furthermore, the development of the concept of numeracy and the increase in research interest in the broader competence of numeracy [16]. Therefore, the decreasing trend in the number of publications on mathematical representation in recent years may be related to the shift in research focus to other topics that are now a priority, such as numeracy literacy in mathematics learning.

3.2. Publikasi Indeksasi Jurnal

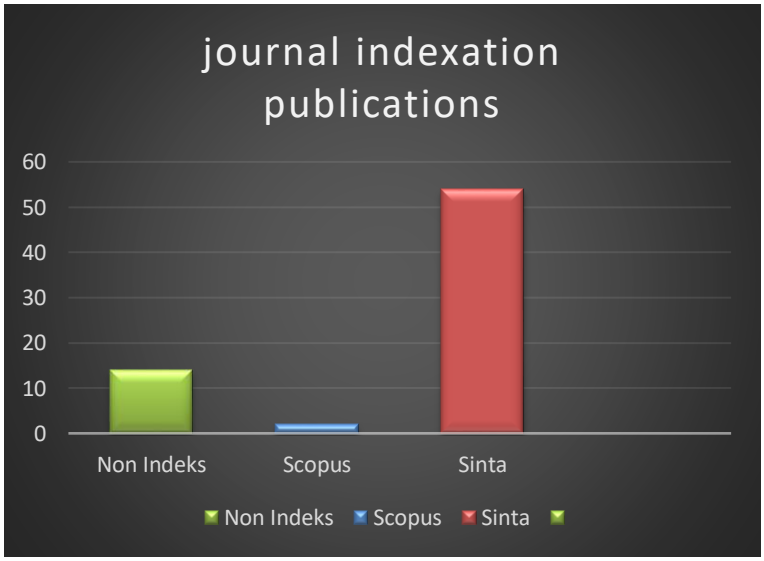

Figure 2. Journal Indexing Publications. Source: Author's dataset.

The results of mapping journal-indexed publications show the dominance of national journals, especially those indexed by Sinta, with a total of 55 articles. Meanwhile, only two articles are indexed by Scopus, while the other 14 articles are not indexed. This indicates that the majority of mathematical representation research remains local, contributing more

on a national scale. The low number of publications in reputable international journals is likely influenced by various obstacles that may be encountered in the process of working on it.

Most mathematics education research in Indonesia employs qualitative methods, and international publications are still relatively few compared to the national total [17]. In another study, it was found that among the 31 articles published between 2013 and 2022, many were local studies, and few explored mathematical representations from an international perspective [18]. From these findings, research in mathematical representation is still dominated by local-scale studies.

Research indicates that many Indonesian academics and researchers encounter significant challenges in publishing internationally, including a lack of confidence in the quality of their research, limited proficiency in the English language, and inadequate institutional support [19]. This condition shows that exploration and publication in the international realm are still limited, so efforts are needed to expand the scope of research. Of course, this indicates the need to improve the quality of research in order to compete at the global level. In addition, this is also a challenge for Indonesian researchers to raise the context of mathematical representation to a broader realm.

3.3. Dominant Research Methods

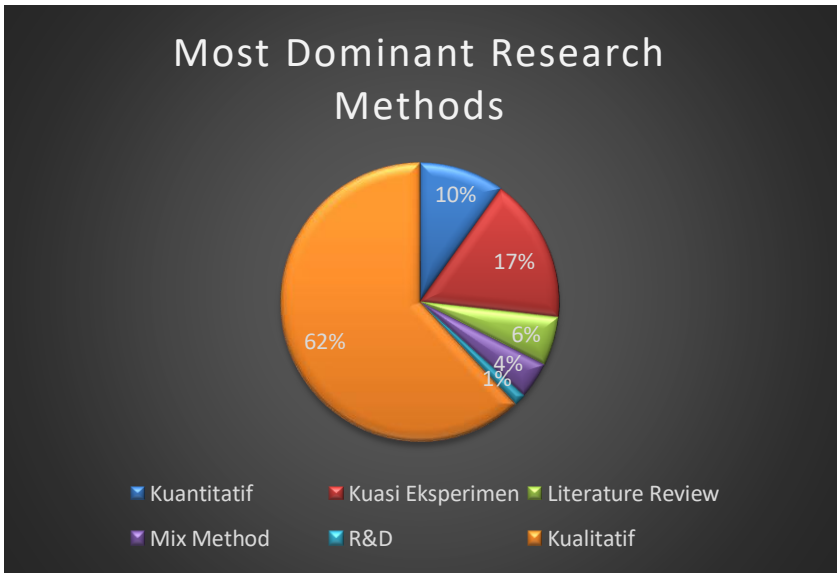

Figure 3. The most dominant research method. Source: Author dataset

Based on the classification of research methods in research publications on mathematical representation ability from 2020 to 2025, it was found that qualitative methods were the most widely used approach in 44 articles, accounting for 61% of the classified article data. Research with this qualitative approach generally focuses on an in-depth understanding of students' thinking processes in displaying mathematical representations, both symbolically, verbally, and visually. This trend is in line with previous research, which shows that most mathematical representation studies are qualitatively descriptive because their primary focus is on the exploration of the thinking process, rather than testing the effectiveness of a particular treatment [20], [18].

Furthermore, the quasi-experimental method was used in 12 articles (17%). In the quasi-experiment method, with the selected samples, namely experimental class 1 and experimental class 2 [21]. Research in this category generally aims to evaluate the effectiveness of specific learning models in enhancing mathematical representation skills. Some of the models that are often used are *Problem-Based Learning* (PBL).

In the quantitative method, there are 7 articles (10%). In this type of research, correlation designs or surveys are generally used to measure the relationship between mathematical representation ability and other factors, such as self-efficacy, learning motivation, or learning independence.

3.4. Articles with the highest citations

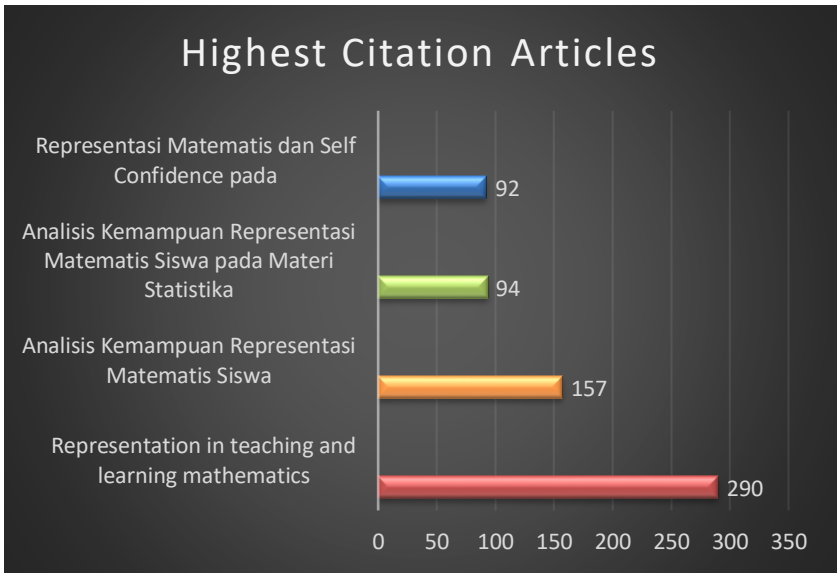

Figure 4. Article with the Highest Citation. Source: Author's dataset.

Publication trends and the number of citations are good indicators of the development pattern of a research field [13]. From the results of mapping based on articles with citations, it was found that several articles had the highest citation rate. The article with the highest number of citations is from the international literature, entitled "Representation in Teaching and Learning Mathematics," with a total of 290 citations. This article serves as the primary reference for various advanced studies that explore how representation is utilised as a bridge between conceptual and procedural understanding in mathematics teaching. This was followed by "Analysis of Students' Mathematical Representation Ability" with 157 citations, "Analysis of Students' Mathematical Representation Ability in Statistical Materials" with 94 citations, and "Mathematical Representation and *Self-Confidence* in *the Reciprocal* Model and *Student Team Achievement Division*" with 92 citations. This illustrates the trend in mathematical representation research in Indonesia, which focuses on the application of learning models and their relationship with affective factors, such as student confidence. The difference in the number of citations between international and national articles also shows a gap in the visibility and reach of publications.

English-language articles published in international journals tend to be cited more often because they have a global audience [19]. In contrast, national publications continue to dominate at the local scale and play a significant role in shaping learning practices in the Indonesian context.

3.5. Dominant Keywords

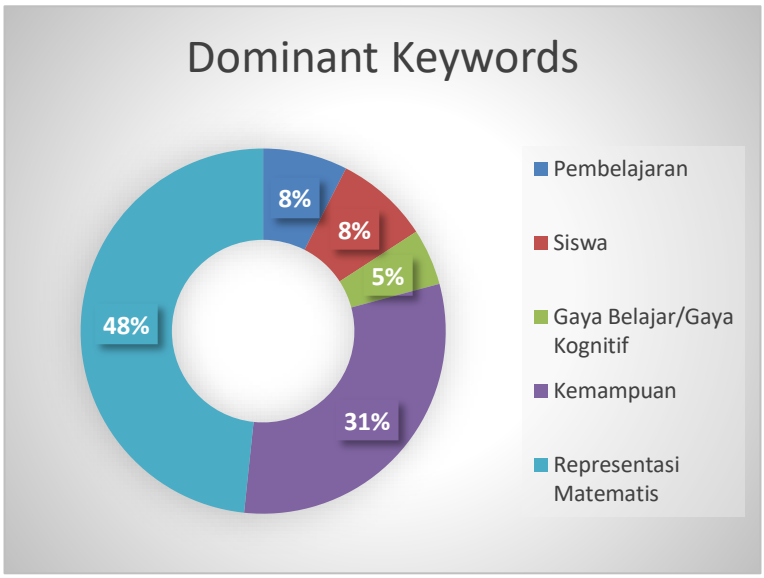

Figure 5. Dominant Keywords. Source: Author's dataset.

Based on the results of mapping 71 article data, five keywords were obtained that appeared most frequently, namely mathematical representation (48%), ability (31%), learning (8%), students (8%), and learning style/cognitive style (5%). The dominance of the keyword mathematical representation shows that this topic is the main focus in various mathematics education research, especially in the context of students' ability to understand and communicate mathematical ideas through various forms of symbolic, visual, and verbal representations.

The keywords' ability' and 'learning' have quite different frequencies, but this indicates that most research not only highlights the concept of representation as a theory but also emphasises its application in the context of teaching and developing students' abilities. This aligns with the NCTM's (2000) opinion that representation is one of the five important process standards in mathematics learning, supporting problem-solving, communication, and mathematical connection skills [3].

Meanwhile, the appearance of student keywords is 8% of the data. At the highest level of education, the sample was used at the elementary, junior high, and tertiary levels [20]. This confirms that the research subject is more focused on students, both at the elementary, secondary, and high school levels. The keywords are learning style or cognitive style, although they have a smaller proportion (5%). One of the factors that can affect learning success is learning style [22]. This shows the direction of research that has begun to associate mathematical representation skills with internal factors of students, such as differences in learning styles, motivation, and self-confidence.

3.6. VOSviewer visualization

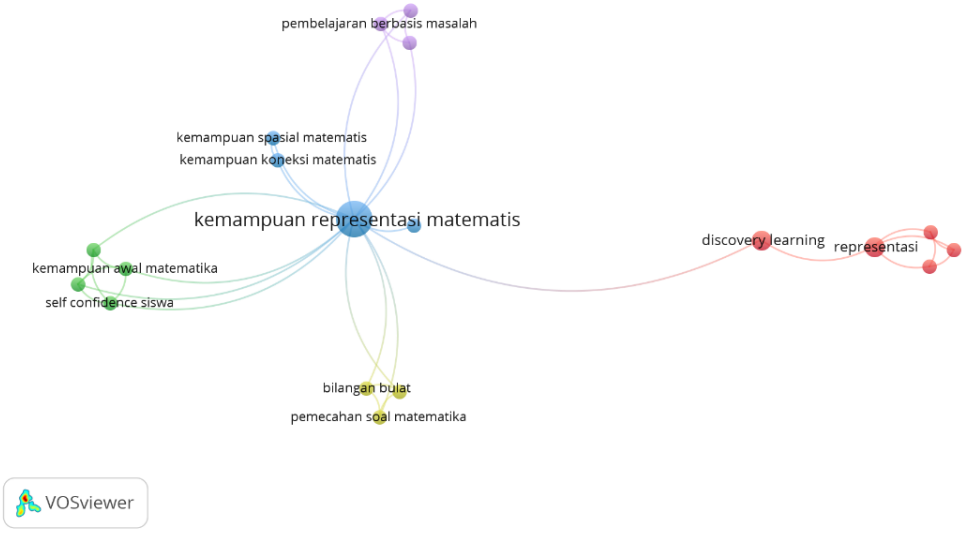

Figure 6. COSviewer visualisation. Source: Author's dataset.

The results of keyword analysis using *VOSviewer* show that the research topic on mathematical representation capabilities is divided into several clusters. The main cluster places "mathematical representation ability" at the centre, signalling the dominant research focus. Some other keywords that often appear together include mathematical connection ability, junior high school students, and integers, which suggests that a significant amount of research is conducted at the junior high school level with basic mathematics materials. Another cluster associates representation with learning strategies such as *reciprocal teaching*, *contextual teaching and learning*, and *discovery learning*, indicating a tendency for research to link representation with innovative learning models. Additionally, the keyword 'early math ability' suggests that student prerequisite factors are also a concern in the study of representation. Thus, the results of this mapping illustrate that mathematical representation research does not focus solely on cognitive abilities but is also associated with material contexts, learning strategies, and other relevant abilities.

4. CONCLUSION

This bibliometric analysis reveals that research on mathematical representation skills in Indonesia has developed rapidly up to 2022, but remains dominated by qualitative studies published in national journals. The results of mapping 71 articles published between 2020 and 2025 show that most publications are published in SINTA-indexed journals (77%), while 2 articles (3%) are indexed in Scopus, and 14 articles (20%) are not indexed in either SINTA or Scopus. This indicates that national publications continue to dominate the contribution of mathematical representation research. Meanwhile, the contribution of international articles is still very limited. Qualitative research methods dominate with (62%), followed by quasi-experimental and quantitative, and the research focus is mostly directed at students. Meanwhile, in terms of subjects, the majority of research focuses on students at the elementary, middle, and high school levels, while

studies involving teachers and learning contexts remain limited. Keyword analysis revealed that the most dominant terms included mathematical representation, ability, learning, and students, indicating that the research focus is more directed towards developing students' representation skills in the mathematics learning process.

These findings underscore the importance of diversifying research methods, expanding publications in international forums, and integrating the study of mathematical representation with pedagogical approaches that focus on numeracy and technology. However, the study has limitations due to the database's coverage, which relies on Google Scholar, and the uneven variation in indexation; therefore, comparisons with the international research landscape are still limited. Further research is suggested to utilise more comprehensive bibliometric analysis tools, such as VOSviewer or Biblioshiny, to explore author collaboration networks, global citation patterns, and the direction of development of mathematical representation topics in more depth.

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